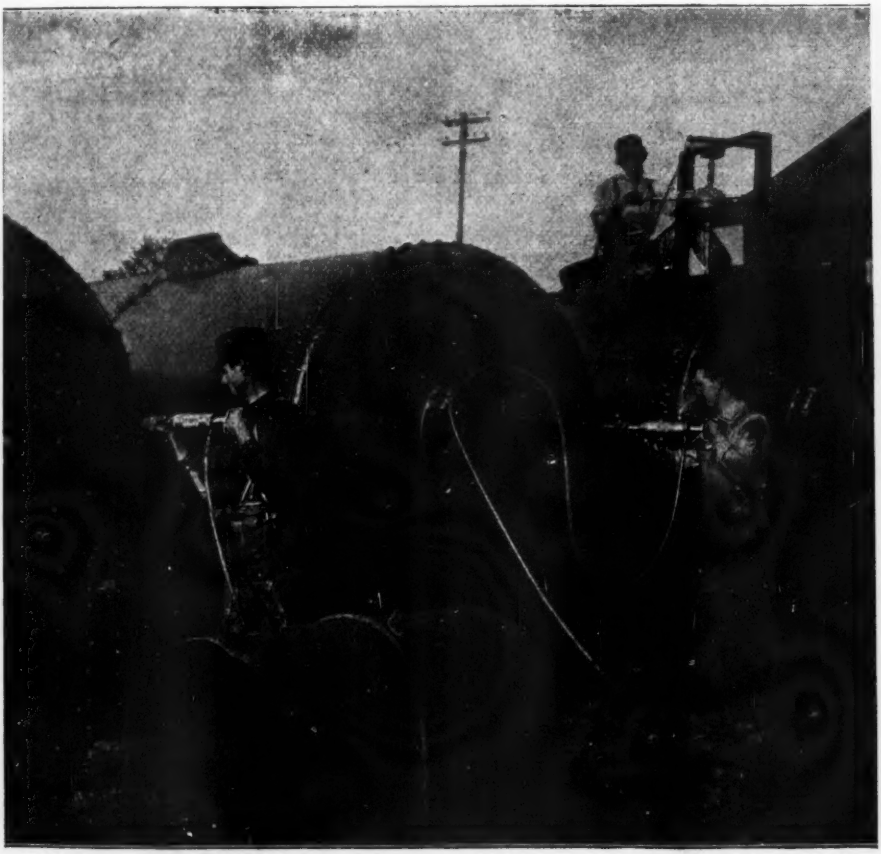
Compressed Air

DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. I. NEW YORK, JANUARY, 1897. No. 11



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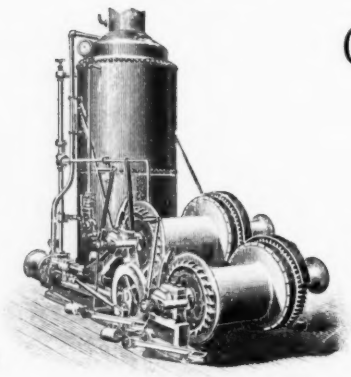

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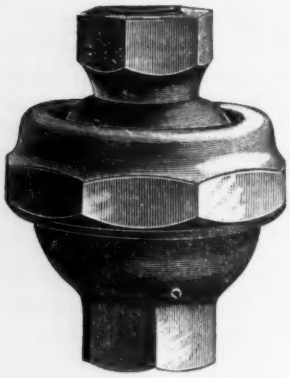

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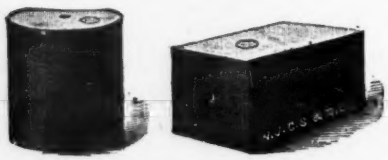

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Compressed Air

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Publisher
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Freezing in compressed air pipes and passages is more frequent in winter than in summer, not entirely because of the low temperature in winter, but because of the increased density and saturation of the atmosphere. On a cold day in January which follows warmer weather, the steam discharged from exhaust pipes rises and floats for a considerable distance before it becomes dissipated. It acts in this respect like smoke. This condition is due to an excess of moisture in the atmosphere because of a shrinkage of volume produced by reduced temperature. When the atmosphere is dry it soon takes up and carries in suspension the steam globules. The same reason accounts for the long wake or foam following a ferryboat in crisp, cold weather, the foam being nothing more than aerated water, which is soon scattered, and partly absorbed by the atmosphere, in dry weather. In a compressed air installation the air-discharge pipes are usually exposed, and are like surface condensers, reducing the temperature of the air which passes through them. If this temperature is reduced below the intake temperature, or the normal atmospheric temperature, there will be a coating of frost deposited on the interior walls of the conduit. The same causes which deposit frost on a window-pane, or which condense moisture on an ice-pitcher, are responsible for the clogging up of the interior of a compressed air pipe. It is well to cover the pipes, and it is still better to enlarge them. A cheap trough. carrying sawdust or manure, preferably the latter, is a good preventive. A large pipe will last longer without clogging through frost for reasons that are obvious. When it is practicable it is best to place all air-receivers out of doors in order to effect as much condensation as possible before the air reaches the conduit. This helps to dry the air, and in some cases more efficient drying can be accomplished by passing the air through a comb or radiator of pipes submerged in cold water, and provided with proper means by which the condensed water is drained off. The aim in all cases should be to reduce the temperature of compressed air to as low a point as possible before it is started on its journey.

Freezing in exhaust passages is more difficult to overcome, but if the air is properly dried at the compressor station, the difficulties about the exhaust will be minimized. All exhaust passages should be large and free of access. It is well not to use exhaust pipes except such as are bell-mouthed or funnel-shaped. As far as practicable, use wood or other non-heat-conducting snbstances around the exhaust. In pumps, a little water admitted from the column to the valve will prevent freezing in the exhanst, because the water gives off its specific heat, and mechanically aids in cutting away the frost.

Some of the Uses and Advantages of Compressed Air.

Read by J. H. McConnell before Western R.R. Club.

Previous to 1890, compressed air was used around railroad shops to a very limited extent. On roads having freight cars equipped with air brakes some of the freight repair yards were fitted with lines of pipe for testing the brakes on cars. For some time air had been used to force couplings into air brake hose and a few shops had air jacks for raising freight and passenger cars.

AIR-DRIVEN BREAST-DRILL.

The air pressure was supplied by locomotive air pumps and the limited amount of air furnished by each pump prevented a very general use of compressed air appliances, as it often required from six to eight air pumps to maintain the supply; more fuel was required in shops of ordinary size to furnish steam to run the pumps than was used to drive all the machinery in the shops. In machine shop practice the use of compressed air was confined to small pneumatic hoists.

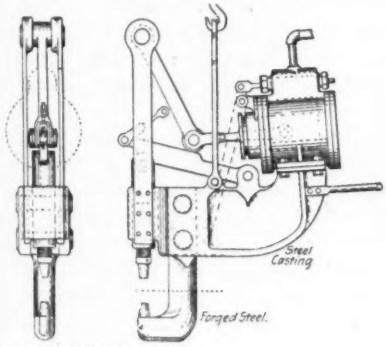
In 1891 its first application to car work was for cleaning the dust from window sashes and blinds in coaches and such parts of the inside as could not be reached with a feather duster, a round nozzle with a 3-32 inch opening being used. This lead to the application of a flat nozzle for cleaning cushions and seat backs, and afterwards for cleaning carpets, bedding and blankets in Pullman cars. The Pullman Palace Car Company recognized its superiority over any other method of cleaning, and where it could be done, contracts were made paying twenty-five cents for the air furnished to clean each sleeper.

Air pumps not being able to meet the demand, an air compressor was added, giving an increased supply, and a new field was opened for air power. Air lifts began to replace the chain blocks or different pulleys at all the heavy machines; the driving wheel lathe being supplied with an attachment to work in a horizontal as well as a perpendicular direction to draw the wheels in or push them out from the centres.

As it required a large number of these lifts in an ordinary railroad shop it was necessary to devise some economical way of making them. By taking ordinary lap welded iron pipe cut to the required length and forcing a wrought iron die through, the pipe was made perfectly round and smooth inside and a leather packing on the bottom side of the piston made a tight piston when the air was applied, and allowed the piston to descend quickly when the air was released. A cast iron head was provided on each end and these were held in place with half inch or five-eights inch rods. A 1¼ or a 1½ inch piston rod was used with a hook and swivel on the end and an eye bolt screwed into the top cylinder head. These parts, together with an inlet and discharge valve, completed the lift. Those which have been in service five years have been very satisfactory and it has not been found necessary to make any change from this method in its lifts raising ten thousand pounds.

The introduction of air into shop practice has brought out, in the last three or four years, a number of valuable and useful tools such as pneumatic drills, pneumatic

hammers, riveting machines for fire box, boiler and tank work; stay bolt cutters and stay bolt breakers. The pneumatic drill performs a very important part in building a new boiler or putting a new fire box in an old boiler. Two men with two drills can tap out the holes and screw in seven hundred stay bolts in a fire box in fourteen hours. By the use of a simple tool attached to the end of the shaft of the drill, stay bolts are screwed into the fire box without a square shank being provided on the end of the bolt, thus avoiding the necessity of forging a square head by which to screw it in. This drill has entirely supplanted the flexible shaft in work



Portable Riveter

PNEUMATIC RIVET DRIVER.

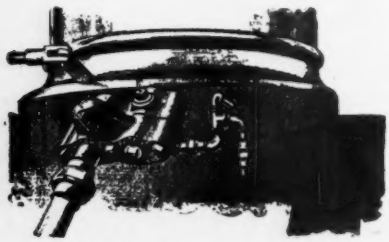
about locomotives, and in some shops a rachet is rarely seen in drilling holes about a locomotive boiler or frame. An air motor is considered an indispensable tool for flue work, and the past three years have not seen a flue fastened in a locomotive boiler except by use of one of these tools. Applied to a cylinder boring bar it will run a good size cut through a cylinder; attached to a valve seat facing machine it does its work quickly and very satisfactorily. It affords a quick and convenient way of grinding steam pipe rings. The pneumatic hammer has also come to stay. For chipping castings, caulking boilers, beading flues and driving rivets, it is one of the most valuable pneumatic tools in service. The application of air to portable riveting machines has done away with a great deal of hand riveting. With the exception of one end of the connection sheet between the cylindrical part of the boiler and the fire box, a boiler can be entirely riveted by air machines,

In car shop work air plays an important part. Jacks for passenger and freight car work are indispensable and any shop can have them if they can buy the castings. They are easily and cheaply made and can be built in any shop having a boring mill or a thirty inch engine lathe. A small jack for raising draw heads, another for pulling down old draft timbers, do not cost much and they save time and labor in doing the work. Sand papering the surface of a passenger coach by an air machine makes better and is cheaper work than can be done by hand. On roads using gas in coaches, an application of a jet of air and gas through a Bunsen burner removes the paint in a very quick and clean manner with no danger from fire. Attach a half inch hose to the gas pipe in the car and another hose on the air supply, connect them both to the burner and see how cleanly and quickly you can burn off a coach. If you mix any paint, make a galvanized iron tank to hold fifty gallons—or make two if necessary—bend a piece of half inch gas pipe in a circle two inches smaller than the inside of the tank, drill about fifteen holes on the top side of the pipe, plug up one end, put an elbow on the other, screw in a piece of half inch pipe about four feet long, put on a globe valve, couple on the air, fill the tank with lead and oil or paste and oil, turn on a small quantity of air and see how quickly it will mix it. The material becomes agitated as if it was boiling. It is superior to any other way of mixing paint and it runs itself.

The use of air for painting buildings and freight cars has been successfully carried on for the past three years. Applied to a

machine for white-washing it will cover a great amount of space; a twenty stall round house can be white-washed in twenty hours. I have seen a machine shop 150 x 200 feet with a trussed roof white-washed, over the walls, the roof and the trusses, in ten hours. For crossings, fences and bridges, it is the cheapest and quickest way; it makes a smooth surface and drives the white-wash into places which a brush will not reach.

In our machine shops air is now as important as steam. It is performing many things better than steam did, as there are many tools about a shop run by air that could not be run by steam. A three cylinder brotherhood engine operated by air is one of the most important tools in the shop. It is mounted on a small iron truck



PNEUMATIC TRACK-SANDER.

and can be readily moved. All complete it does not weigh over two hundred pounds. It will run an 18 inch slotter, a 42 x 42 inch planer; it will run a small driving wheel lathe and turn tires up to 56 inches in diameter; it will run a lathe for turning steel tired car wheels; it will run a drill press, a bolt cutter or any single machine, and frequently it will save running the whole shop when it is necessary to run one machine only. A press for rod work, driving box brasses, or other work that does not require over 15,000 pounds on the piston is a great improvement over the old screw press and much quicker.

An emery wheel driven by air on the principle of the Pelton water wheel makes a very handy tool for light grinding, two six inch emery wheels on one shaft can be run from a quarter inch pipe. A transfer table of one hundred feet travel can be successfully run by air by using a small engine.

Among the many uses of air in our shops that of blowing out steam passages in cylinders commends itself at once. To do this fill the boiler with air at 100 pounds pressure, blow out the ports, put in the pistons, fill the boiler again with air and run the engine out of the shop into the round house. You have burned no wood, nobody has waited for the engine to get hot and you have saved several hours in time in finishing the engine. In testing stay bolts with 100 pounds of air pressure on the boiler a broken stay bolt is immediately detected when sounded with a hammer, when it might not be discovered if sounded when the boiler was empty or full of water.

At the scrap pile a cheap and effective shear for cutting off bolts to length can be made by using two short pieces of sixteen inch "I" beam and a passenger car brake cylinder which can be made to work automatically or by hand, A freight brake cylinder set in an upright wooden frame with an anvil below and a steel head on the end of the piston rod makes a good automatic hammer for straightening bolts and rods. The valve motion to the hammer consists of an ordinary three-way cock with a lever attached to the plug and a half inch rod connection to the end of the piston rod. The supply of air regulates the stroke. It can be regulated as closely as a steel hammer and will strike two hundred blows a minute if desired. These tools can be located anywhere about a yard.

A sixteen inch cylinder makes a press for the tin shop and with the proper dies and stamps the largest part of your tinware can be cut out, stamped and flanged, ready to be put together. Galvanized iron water pails, dope and other buckets, are made in this way in pieces. The sides are cut out

in sections, two sections forming the pail. The bottom is cut out and flanged at one blow. The tops and bottoms of tin or galvanized oil cans are made this way; also engine oilers, oil cans, spouts, tallow pots, water glass lamps, and a great variety of tinware can be made more cheaply and quickly than by hand.

Attach a small air cylinder to the splitting shears in the sheet iron shop and you have a very effective shear for splitting sheets from three-sixteenths of an inch in thickness down.

A portable forge for rivet heating and light blacksmith work is made by using a three inch iron tube below the fire plate. Extend this down below the bottom of the forge, connect a quarter inch gas pipe, use an elbow on the pipe, screw in a brass nipple with a 1-32 inch hole for the discharge, place the top of the nipple there ⅜-inch above the bottom and in the centre of the tube and use a quarter inch globe valve to regulate the supply of air. With this forge rivets can be heated faster than two gangs can drive them, and a welding heat can be made on a bar of two and one-half inch round iron.

In the office attach an eight inch cylinder to the letter press for copying letters; you will like it so well that you will not want any more screw letter presses.

The application of air in a sand house as a means of elevating sand to a tower where it can be discharged through a spout into the sand box of the locomotive has been adopted on a number of railroads. A passenger car auxiliary reservoir with the necessary air connections makes a convenient and economical machine for kindling fires in locomotives with oil. In a blacksmith shop a blast for all fires can be supplied by compressed air and the fan blast dispensed with, experiments in this direction having demonstrated the success of this plan.

New applications of air are constantly being made about railroad shops, each new application suggests another, and no shop is complete at the present time without an air compressor. Even small shops can afford to dispense with locomotive air pumps and buy a compressor, because one that will furnish as much air as six pumps can be purchased for about $800.00.

AIR DRILL AND REAMER.

The economies effected by the use of air will, in a short time, pay for a complete air plant. A large reservoir supply is a great advantage, the larger you have it the more economically can the system be operated. A machine shop to-day can be fitted up to a better advantage and for less money than ever before. No main line shafting extending the entire length of the shop is

necessary. A short line shaft may be used for heavy machinery and all the light machinery may be driven by air.

The last five years have produced many useful compressed air tools and the future will bring out others. Manufacturing establishments are investigating the advantages of air, and all railroad shops are more or less engaged in bringing out new appliances so that we are looking to the future and wondering what will be the next application of compressed air in shop practice.

Advantages of Compressed Air for Transmitting Power.

In a communication to the Société de l'Industrie Minérale of France, M. Mortier made a critical examination of the advantages and disadvantages of compressed air as an agent for the transmission of power, showing clearly by mathematical calculation, that the advantages far outweigh the disadvantages. We have not sufficient space to reproduce this valuable treatise, but we select the more practical portions and also the conclusions arrived at by the eminent inventor of the diametral ventilator.

While compound air compressors have already been adopted to a certain extent, the use of multiple expansion has hitherto been limited to a compounding of the motors, the reason of which limitation must be sought in the fact that compound engines cost more than those not compounded, while it is difficult, without warmed intermediate receivers, to restore its initial temperature to expanded air. Instead, however, of compounding each compressed air motor independently, it would be better to compound them mutually, the exhaust air from one series of motors being collected for supplying another series in a pipe under moderate pressure, laid side by side with the high pressure mains.

There is, moreover, nothing to prevent various lengths of this supplementary pipe from being connected, first with one another, and afterwards with the receiver of the successive compressors, in which case a series of compoundings would be obtained, notwithstanding diffierences in the volumes of air exhausted from the two series of motors, and in this manner something akin to the system of electric distribution with three conductors would be effected, without, however, its complication.

Besides great saving in the first cost of the motors, a mutual compounding would give them considerable elasticity of power without loss in yield, because with two pipes under different pressures, a moderate effective pressure, double or triple, according to the method of connecting the admission and exhaust, may be applied to the same cylinder. Advantage may thus be taken in the same cylinder with normal dimensions of the original economy afforded by low compression, because the possibility of admitting a threefold pressure would permit of overcoming a special resistance of making unusual efforts. In this manner successive stages of compounding introduced into the utilization apparatus would greatly increase the useful effect of moderating or governing, by permitting the dimensions of the motors to be reduced and the wire-drawing of the compressed air in the cylinder to be diminished.

The co-efficient of general yield, taking into consideration the imperfect general yield, the losses of work corresponding with losses of pressure, and the advantages of multiple compressions at the beginning and end of the operation, is calculated mathematically by the author, who concludes that if only the adiabatic method —that at equal pressures—be adopted, which most nearly approaches the ordinary conditions of practice, the following useful effects will be obtained:—With a single compression, 0.533; with a double compression, 0.681; and with quadruple compression, 0.753.

These figures suppose the most unfavorable conditions that can occur, *viz.*: no cooling down in the compressing cylinders and no reheating in those wherein the air is again expanded; but at the same time they suppose the favorable condition of the air returning to its initial temperatures after each stage in the multiple compression. Although a quadruple compression may be obtained perfectly well, a double expansion is all that can be hoped for in practice. Taking everything into account, it will be very near the truth to regard the original yield or useful effect as varying between 55 and 75 per cent.

Simple air compressors of good construction show a ratio of 0.85 between the work indicated on the air pistons and that on the steam pistons, or 0.93 for the yield of the air system and 0.93 for that of the steam system, while for the receptor motors only a rough mean can be given, probably near upon 75 per cent. The maximum value of the general useful effect, supposing the pipes absolutely tight, will therefore be $0.75 \times 0.93 \times 0.75 = 0.523$; but without multiple compressions this figure will be only 0.384, supposing the work of expansion to be completely utilized, which is practically impossible with a single expansion without reheating.*

As is well known, the compression of air in a space which exerts no action upon it causes heating, while expansion in a similarly inert space causes cooling, and with production or utilization at constant pressure the variation of temperature may be obtained in centigrade degrees by dividing the work (expressed in kilogrammetres* per kilogramme of air) by 102.7 F.

To give an example for an expansion at constant pressure corresponding with a ratio of 6.25, the theoretical lowering of temperature will be 120° cent., while for a ratio of 2.5 it will only be 60° cent. In the former case, working would be impossible owing to the oil becoming solidified, and the watery vapor in the air being frozen; but in the second case admissible conditions may be obtained, especially if the exhaust be allowed to commence at a pressure slightly greater than the back pressures.

Thus, not only does the use of multiple expansions improve the useful effect, but even renders it possible, which would not otherwise be the case. If the initial temperature of utilization be not the same as that of production, the useful effect found for identity of initial temperature must be multiplied by the ratio of the temperatures.

The yield may be increased (1) by lowering the initial temperature of production, although little more can be practically done in this connection than to draw the air for compression from a cool cellar and (2) by raising the temperature of the compressed air immediately before it is utilized. The available energy is then, as it were, expanded under the action of heat, just like air itself, and with the same coefficient of expansion, the improvement thus obtainable having theoretically no limit, so that the yield of a power transmission by compressed air may be considerably greater than unity; and it is in this respect that compressed air differs widely from the other agents for transmitting power such as electricity and water under pressure, which admit of no such increase, and always yield less work than what has been entrusted to them.

It is evident that this "expansion," or increase of energy, cannot be obtained without the consumption of fuel, but this supplementary work is obtained so cheaply and simply that no other is more economical, not even the natural forces, which are regarded as gratuitous. In any case, whether the expansion leaves the air at a relatively high temperature or whether it determines an intensely refrigerating action, a difference will be set up that may be utilized mechanically so that some of the heat imparted will be recovered, thus reducing expense.

Indeed there is a case in which the saving that may be obtained is absolutely integral, viz.: when the expansion supposed forms one of a multiple series in which the initial temperature becomes raised by the reheating every time to the same figure, and in that case the residual temperature of the air at the end of each partial expansion constitutes a net gain for the next reheating.

For a multiple utilization, comprising a certain number of stages, each corresponding with the same ratio of compression, with the same initial absolute temperature reheated, and consequently with the same sum of work produced, the mean thermic yield, which in this case is the arithmetical mean of the partial yields, may in any case rise above 50 per cent. even, under ordinary circumstances.

Considering that the cylinders of gas engines readily accommodate themselves to high temperatures, an exact doubling of the energy available at the end of the operation, *i. e.*, an integral reconstitution of the energy furnished at the commencement may be obtained—and this with a very slight expenditure of heat units, inasmuch as the operation of reheating has a thermic yield ten times that of good engines.

The multiple compression of air by the natural forces, its transmission at high pressure, and its expansion in a series of stages after considerable and repeated heating, afford a very welcome solution of the problem of the economical production and transmission of power; and this system, economizing the natural forces, the effect of which it multiplies, and the fuel which it consumes, offers nothing but what is very acceptable, provided the pipes be perfectly tight, which however is unfortunately not yet attained in practice. The following is a summary of the conclusions arrived at by the author :—

Compressed air, regarded as an agent for transmitting power, is just what it is made, its value being exactly proportioned to that of the mechanical and calorific conditions which preside at its production and utilization. With high adiabatic compressions, rendering illusory all effective expansion, the yields obtained are miserably small; and on the other hand, although with low pressures this original defect is absent, the dimensions of the pipes and apparatus then become so large as to be prohibitive.

With a series of successive compressions, however, even at constant pressure, and especially with a mutual compounding between motors, sufficiently far apart for the air partially expanded in passing between them to acquire the surrounding temperature, a useful effect of 50 per cent. may easily be obtained, and that with pipes and cylinders of moderate dimensions.

While the other agents of power transmission, such as electricity and water under pressure, correspond with a strictly defined amount of energy available, compressed air, in addition to the amount of work which it is capable of giving out at a constant pressure and at the surrounding temperature, carries with it a credit, theoretically unlimited, for transforming into power the artificial heat which may be communicated to it; and this transformation is effected with so high a thermal yield that the supplementary work thus obtained is almost gratuitous.

In other words, the purchaser of a given weight of compressed air acquires at the same time the right of obtaining, without complication of any consequence, and with a very slight expenditure of fuel, an artificial quantum of energy at least equal to that of the natural energy imparted to it directly.

This special faculty added to absolute elasticity of speed, both of the compressors and the motors, and also to the possibility of regulating or storing up compressed air, constitutes an individual feature of the highest importance, which may often justify a preference being given to this agent of power transmission.

* A kilogrammetre (7.233 foot-pounds) represents the effort required to raise a kilogramme (2.2 lbs.) the height of 1 metre (3 ft. 3⅜ in.).

J. W. PEARSE.

Some Figures on the Cost of Pumping With the Pohle Air Lift.

The Pohle Air Lift Pump is one of the most valuable of the many applications of compressed air, and though comparatively new, its developments have been rapid. It has been applied widely to the raising of sub-surface waters which lie below the reach of suction pumps, and in some instances it has replaced the suction pump where the conditions did not imperatively call for the air lift system, because of its many advantages. Many manufacturers located along the banks of rivers, lakes, etc., who are now obtaining their water by means of crude direct acting steam pumps or through the city or village pumping station, can reduce the cost of the water supply materially through the use of a pneumatic pumping plant. There are few figures available as to the cost of pumping under this system, and the following may be of interest.

We will assume a manufacturing plant, say 1000 feet away from the best location for wells, or from a surface body of water. In the latter case the pneumatic displacement pump may be used, hung from piles or otherwise suspended in the water. The air lift may be used by drilling wells close to the edge of the water, or a better quality of water in sufficient volume is often obtainable from driven wells some distance away.

With the air lift the plan of pumping involves the use of an air compressor located where the expense of attendance is least; an air receiver adjacent to this compressor; a pipe line for conveying the air from the receiver to the wells; a number of wells drilled to a depth proportionate to the height of lift and the depth of the water strata below the surface; air and water pipes running down inside these wells representing the pumping apparatus proper; a tank located close to the wells and at such height that the water flows by gravity to the point of consumption through a distributing system of pipes carried beneath the reach of frost.

In many cases the introduction of the air lift may be effected at little expense, often involving the purchase only of an air compressor, a receiver and a small amount of pipe, but in the following it is proposed to estimate on a basis which will cover the greatest amount of expense likely to be incurred with a view of showing particularly that the interest and depreciation charges under the most extreme conditions are not under any circumstances likely to develop into formidable figures. The following figures are all approximate and are intended to be in all items well on the safe side.

Estimated cost of Air Lift Plant to raise 1,500,000 Gallons per Twenty Hours, or 1,250 gallons per minute. Total lift, seventy-five feet.

Duplex air compressor complete ready for foundation and piping, estimated	$2500.00
Air receiver	135.00
85 H. P. of boiler with feed pumps, etc., bricked up and ready for use, including building and value of ground so occupied, at $15.00 per H. P.	1275.00
Tank say 19,000 gallons capacity (15′ x 14′ 6″) including suitable timber frame work to bring tank 75 feet above water level	300.00
Two 12 inch wells, each 135 feet deep, cased, at $4.00 per foot	1080.00
450 feet 7⅝ inch light casing (water discharge pipe) at 60 c. per foot in place	270.00
500 feet of 3 inch casing (air pipe in wells) at 15 c. per foot in place	75 00
1,000 feet of 4 inch air line from receiver to wells at 23 c. per foot in place	230.00
1,250 feet of 12, 10 and 8 inch cast iron distributing main, leaded joints, from tank to works, laid be-	

low frost (air line laid in same trench) at $1.00 per foot..... 1250.00

All pipe and fittings not covered in the above estimate say..... 150.00

Compressor, receiver and tank foundation, say 18,000 brick laid in cement at $12.00 per 1,000..... 216.00

Excavation for foundations, say 75 cubic yards at 33⅓ c. per yard 25.00

Allowance for ground space and buildings occupied by compressor and receiver..... 400.00

Special automatic governing mechanism..... 75.00

Erecting and starting expenses of compressor plant..... 75.00

Freights..... 100.00

Royalty 400.00

Contingencies, sundries, etc.,... 164.00

Total estimated cost of complete plant ready to run as above.....$8750.00

As before stated, this is intended to include everything which may be considered as a legitimate expense in this connection. In many cases the buildings, boilers, tanks, wells, pipe lines, ground space and other items do not represent a present expense, being already on the ground. From the above figures we may estimate the cost of operation as follows:

COST OF OPERATION.

Engineer double shift at $2.25 per day, $4.50; 1-5 time chargeable to pumping plant, per day..... $ .90

Fireman double shift at $1.75 per day, $3.50, on the basis of one man required for each 250 H. P. of boiler for 85 H. P. per day 1.19

Fuel, 85 H. P., 20 hours, say 4¼ tons at $2.00 per ton, per day..... 8.50

Oil, waste and sundries, say..... .60

Interest on investment of $8750.00 at 5%, figuring eleven 25 day months or 275 working days per year, per day..... ..... 1.91

Deterioration, covering sinking fund, repairs, etc., providing for renewal of complete plant every ten years, same basis as interest but 10%, per day 3.18

Insurance and taxes 1% as above per day..... .32

Total estimated cost of pumping 1,500,000 gallons per day, 75 feet high, under the above conditions.. $16.60

Cost of each 1,000 gallons ($16.60 + 1,500), $0.01107.

Kent, quoting the National Meter Co. as authority, gives the cost of water in the states as follows:

Average minimum price per 1,000 gallons in 163 places, .094.

Average maximum price per 1,000 gallons in 163 places, .28.

With extremes ranging from 2½ c. to $1.00 per 1,000 gallons.

As a usual thing the water rate in most manufacturing cities in the Central States runs in the neighborhood of 8 c. to 10 c. per 1,000 gallons supplied. In some of the larger eastern cities it runs up to 12½ c., and even higher for manufacturers, and in some cities of the second and third class goes as low as 5 c. per 1,000 gallons. At 5 c. per 1,000 gallons, the yearly water bill on the above basis amounts to..$10,625.00

And at the figure given above, 01107..... 4,566.37

A yearly saving on the above basis of..... .....$ 6,058.63

This equals a profit of 69 1-5% on the estimated investment of $8,750.00, or is the same as a dividend of 20% on an investment of $30,293.15. With the actual cost of the plant less than is figured above, as it would really be in the majority of cases, the saving would show still better. In many cases the operation of the plant does not involve the extra expense of engineer and fireman, and these items may be deducted. In other instances the fuel cost, either through the use of high duty air compressors or through lower cost of coal, may amount to much less. The only other items which amount to much are those of interest and deterioration, and we have

already seen that these have been taken on the outside extreme. In a plant pumping about 3,000,000 gallons per 20 hours 75 feet high, where the cost of the fuel delivered is 85 c. per ton, but the other expenses are figured even more liberally than is shown by the above estimate, the cost per 1,000 gallons is about, .0084 cents.

And in the same case, but pumping 50 feet high, about .006 cents.

In another case involving the handling of about 15,000,000 gallons of water 30 feet high every 24 hours, using compound condensing compressors, and with coal at $2.00 per ton other figures being estimated on a very generous basis, the cost nets about $2.50 per million gallons; or about 2½ mills per 1,000 gallons. In many cases a belt compressor may be used, bringing the under-loaded factory engine up to an economical load without involving any extra expense for attendance or fuel. Such plants can after be put in at comparatively little expense and will frequently pay for themselves several times over in the first year. The cost of pumping does not run very high per 1,000 gallons, even in the smaller plants, and when used on a large scale the system compares very favorably indeed with the best of other methods. In some cases water of inferior quality is being used at a considerable disadvantage because of its accessibility. In one instance river water highly impregnated with sulphur coming from coal mines above, resulted in an expense of $5.00 to $8.00 per day from the grooving and pitting of rolls in a steel working establishment. The effect on the boilers was very bad and represented an important item of expense in repairs and extra fuel burned. In such a case as this it might be well to go off even a mile to sink wells in some desirable location, the superior quality of the water so obtained reducing in many ways the cost of manufacture. Again, with a copious and inexpensive water supply condensers may be attached to the main engine resulting in a saving of 20% to 30% of the whole fuel bill. In some instances deep well pumps have been thrown out and the air lift installed, primarily because of the thorough æration of the water resulting in throwing off most of the sulphur and other objectionable qualities. Where river or other surface water is good the wells may be drilled close to the edge, the water flowing down from the top of the wells, and the system automatically adjusts itself to any variation of the river level. In many cases where there is a heavy strata of sand or gravel level with the river bed, this strata may be used as a natural filter by placing the wells some distance away and the quality of the water much improved.

Where a part of the water only is used at a high elevation about the works, it is an easy matter to put in a supplementary air lift taking its supply from the distributing main and raising it in a second or compound lift to the point desired, thus avoiding the expense of raising the whole volume of water to the full height. The compressed air may in many instances be used to great advantage for other purposes about the works. There are already some 70 or 80 different applications of compressed air in railroad machine shops, and there is hardly a manufacturing business of any kind in which the use of compressed air would not reduce materially the expense in some important departments.

Properly installed, little care from a competent engineer is required. The compressor may be arranged to be regulated by the water consumption so that the fuel consumed is proportionate to the amount of water used, thus leaving little for the engineer to look after except to see that the oil cups are kept filled. In point of durability the air lift stands by itself. There is nothing about the two plain open-ended pipes in the well to require attention until they are rusted through. A good air compressor requires no more expense in this direction than any good

steam engine. Using steam hot from the boilers with an economical rate of expansion the condensation is reduced to a minimum. It is a common sight to see a long line of steam pipes running down to a direct acting pump a considerable distance from the boiler. Authorities estimate that with fuel at $2.00 per ton, every 2″ pipe uncovered costs $1.00 per year for condensation. With air there is no condensation. The direct acting form of pumps referred to frequently require fron 175 to 200 lbs. of steam per H. P. per hour, while an economical air compressor does its work on 15 to 40 lbs., according to type. The common form of water pump frequently consumes 50% of its power overcoming its own friction. The friction of a good air compressor is usually down to 10%, and may run down to 5%. A careful study of the system will prove very interesting, and it will often be found that it pays well to use the air lift even in those exceptional cases where the cost of the water is not materially reduced because of the other incidental features in economy.

As the figures given may create the impression that the cost of pumping with a small plant may run disproportionately high, we will investigate in that direction also. In most small plants an inexpensive belt or steam actuated compressor may be used, entailing no additional attendance expenses and no extra boiler, building, or tank investment, and in some cases there would be no additional cost for well, piping, etc. Excluding tank, boilers and building, but making proper allowance for well, piping, steam driven compressor, receiver, foundation, freights, erection, etc., assuming that the tank and well are close to the work, we find that for a plant to pump 175 gallons per minute, or 252,000 gallons per 24 hours, 75′ high, the total investment is not likely to exceed $1,500.00. The interest, deterioration, insurance, and tax charges, as above, aggregating 16% net on this sum per day.....$ .87

A proportionate allowance for fuel at $2.00 per ton, attendance, oil, etc., should not exceed per day 2.50

Total cost of pumping 252,000 gallons per day.....$ 3.37

Cost per 1,000 gallons..... .01⅓

Cost of this amount of water at 5 c. per 1,000 gallons, per year of 275 days.....$3465.00

And at 1⅓ c. per 1,000 gallons.. 924.00

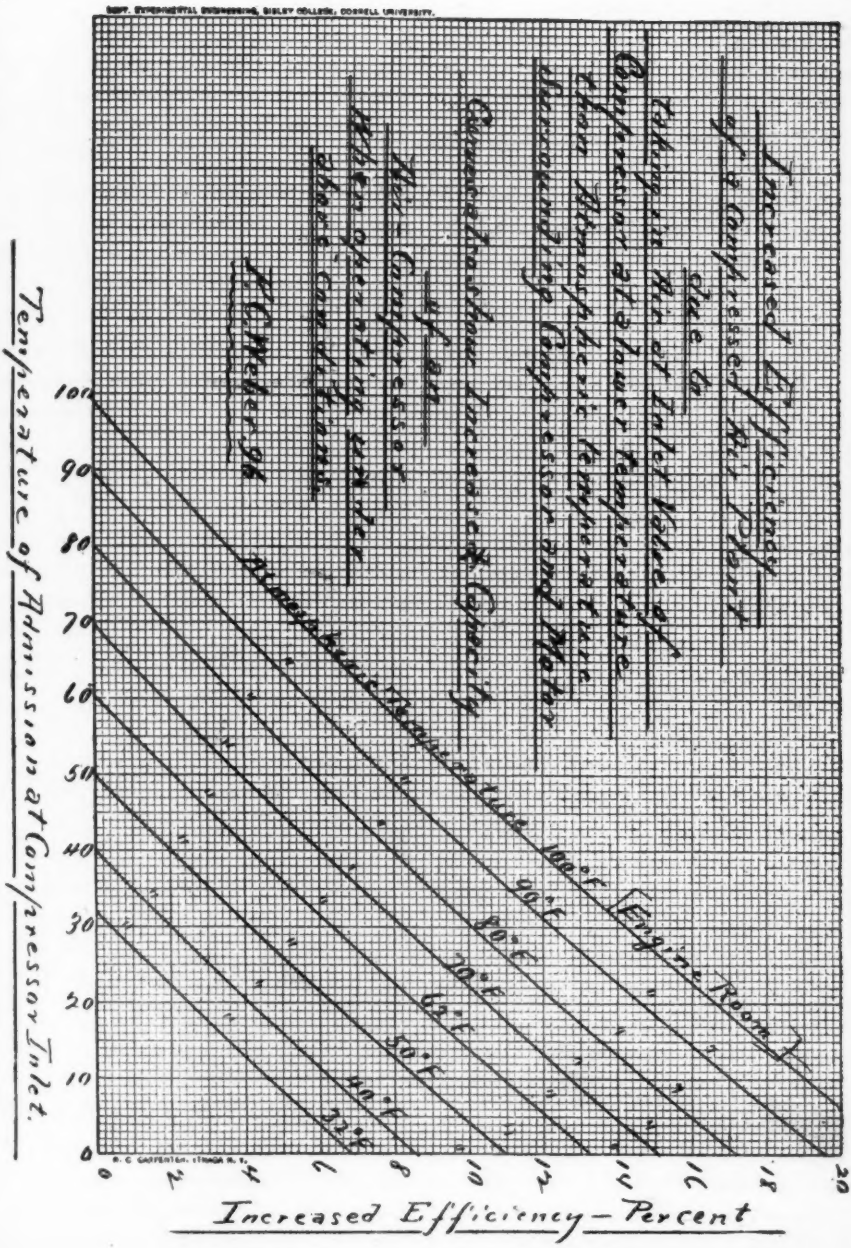
Net saving effected per year with a plant costing $1,500.00.....$2541.00

or a dividend of 169% on the investment. Certainly one had better borrow the money, even at a high rate of interest if necessary, rather than neglect such a saving as this. In many instances a surprising saving may be effected when the water is now being obtained by means of deep well pumps or other similar apparatus, by throwing the outfit aside and installing the more economical Air Lift System.

GEORGE R. MURRAY.

Pneumatic Cesspool Excavator.

A pneumatic apparatus for emptying cesspools has been invented by english manufacturers and is now in use at Pokesdown, England. It consists of a tank for sewage and a dome and connecting pipe for producing a vacuum in the tank. The tank is mounted upon an ordinary four-wheel truck and can be drawn by a horse. A smaller portable truck supports a vacuum pump. Two men can work it and produce enough power to create a vacuum in the tank. The pump is connected to the dome by means of flexible pipe, and the gases arising by the exhaust of the air are forced to an upright boiler shaped stove and burned. The vacuum of course causes the material to rise from the cesspool and the tank is filled and carried away. None of the material is brought to view or comes in contact with any of the machinery.


Dept. Experimental Engineering, Sibley College, Cornell University.
Increased Efficiency of Compressed Air Plant due to Cooling the Air at Inlet before Compression at Lower Temperature than Atmospheric Temperature
Increased Efficiency of Compressed Air Plant due to Cooling Jacket Water
Combined Jacket and Intercooler Capacity
Air Compressor
Water Circulating Pump
Water Circulating Motor
H. C. Weber '96
Barometer 30 Inches
Atmosphere Temperature 100° F. (Engine Room)
90° F.
80° F.
70° F.
60° F.
50° F.
40° F.
33° F.
Temperature of Admission at Compressor Inlet.
Increased Efficiency—Percent
0
2
4
7
8
10
12
14
16
18
20
0
10
20
30
40
50
60
70
80
90
100
R. C. Carpenter, Ithaca, N. Y.

Increased efficiency of a Compressed Air Plant.

It is generally known that the efficiency of a compressed air installation can be increased if the air is taken into the air compressor at a lower temperature than that of the air in the engine room. To show just what this increased efficiency amounts to for various conditions, the curves on page 170 have been prepared, and will illustrate the gain very clearly.

Take a case when the engine-room temperature is 100° F., and the intake air having a temperature of 48° F.; then by reading along the line 48° until we strike the temperature curve 100, and from that point reading perpendicularly, we obtain the per cent. of gain—*i. e.*, 9%. If the temperature of the engine room is 80° F., and admission temperature 23° F., then gain in efficiency is 10%.

F. C. WEBER.

COMPRESSED AIR.

(CONTINUED.)

In the usual air-compressor plant the free air is taken in from the engine-room. This is a mistake which is so apparent that it is difficult to account for its existence. It is not only desirable to compress clean, dry air (which is not usually found in the engine-room), but the economy and capacity of an air-compressing plant are largely dependent upon the temperature of the intake air. A low temperature increases the capacity, and adds to the efficiency of the machine.

A concentrated inlet connecting the valves with a point outside the engine-room is the best construction A chimney made of wood will serve the purpose very well, though cooler air can be obtained by drawing it from a well. The presence of water in the well is no disadvantage, provided the water is cold. The intake air might advantageously be passed through cold water, or subjected to a spray of water for the purpose of reducing its temperature and destroying the impurities.

For every five degrees that the temperature of the intake air is lowered below that of the engine-room, there is a gain of one per cent. in volume. In summer only a few degrees difference can be obtained but in winter the difference between the air inside and outside is often fifty degrees.

Mr. E. Hill has compiled the following table, showing the discharge of a compressor having an intake capacity of 1,000 cubic feet of free air per minute; the temperature of the intake air varying from Zero to 110°, and in each case being discharged at a uniform temperature of 62° F., and at atmospheric pressure:

Temperature of Intake Air.	Volume taken into Compressor.	Volume discharged, if measured at 62 degrees and atmospheric pressure.
0	1000 cubic ft.	1135 cubic ft.
32	1000 "	1060 "
62	1000 "	1000 "
75	1000 "	975 "
80	1000 "	966 "
90	1000 "	949 "
100	1000 "	932 "
110	1000 "	916 "

Mr. R. A. Parke, in a paper read before the New York Railroad Club, illustrated the great importance of supplying the compressor with cold air, as follows:

"With an ordinary single-stage com-

pressor, furnished with no cooling appliance, the delivery temperature of the air at the compressor is about 437 degrees. It may be assumed that, in every ordinary case of transmission, the temperature of the air falls to that of the locality where it is used, with an accompanying shrinkage of volume, so that, in the present example, the temperature of the air used would be 60 deg., and each cubic foot of air delivered at the compressor shrinks to .58 cubic feet before being used. If the temperature of the atmospheric air received in the compressor were 40 deg. instead of 80 deg., the delivery temperature would be but 371 deg., and, when cooled to 60 deg., the shrinkage of each cubic foot delivered would be only to .626 cubic feet. Thus eight per cent. greater volume of atmospheric air, at a temperature of 80 deg., must be compressed than would be necessary if the temperature of the air were 40 deg."

Low temperature of intake air is so important that the plants established for the purpose of compressing air for power distribution should be located with this question prominently in mind. An ice making plant, or a cold-storage room, is the best place for an air-compressor. In such a place as this, with the temperature of the intake air at or near zero, the compressor, provided with compound cylinders jacketed by a circulation of cold brine, and thoroughly cooled between the stages, we might produce compressed air at a low temperature and a high efficiency. This cold; dry air, distributed over or under ground (thus increasing its temperature in transit), and heated before use, might develop an efficiency beyond that which is possible in the use of electricity, hydraulics, or any other form of secondary power.

W. L. SAUNDERS.

NOTE.—A valuable use for compressed air has been found in power stations of electric street railways. In the Terre Haute Electric Railway station an air compressor furnishes air at 40 to 50 lbs. pressure, and this is used with hose for blowing the dust and dirt out of the armatures, dynamos, etc. Its use is found very valuable for this purpose. It is also used for cleaning out street cars, etc. Here is an instance showing one of many cases where compressed air and electricity supplement each other, the air doing what electricity could not possibly be made to do.

A recent test of the American Air Power Company's compressed air car, No. 18, was made with the most gratifying results. It travelled ten miles doing regular work.

The car performed a perfect service, and readily climbed grades of varying percentages. The entire trip was made with one charge of air, with a large reserve at the conclusion.

This is one of the two cars that have performed a service of 19,000 miles on 125th Street since last August, without delay or accident.

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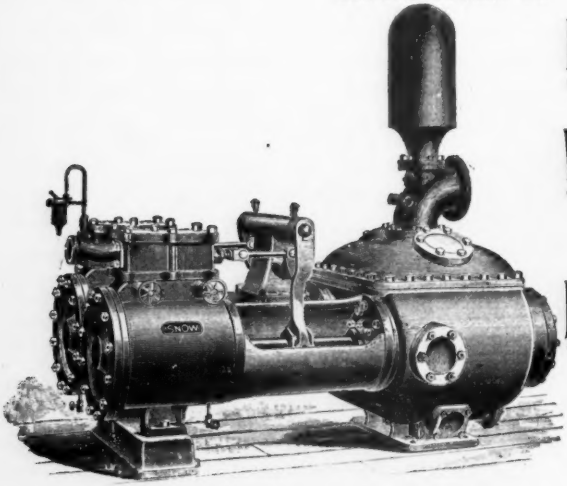

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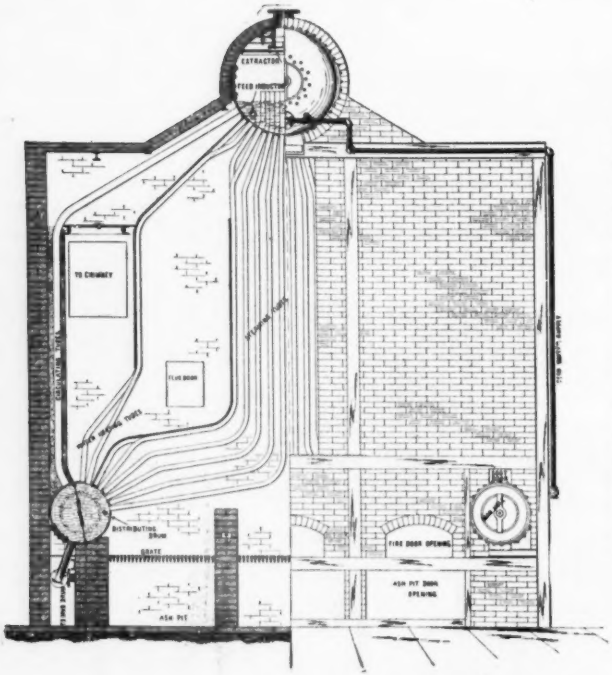

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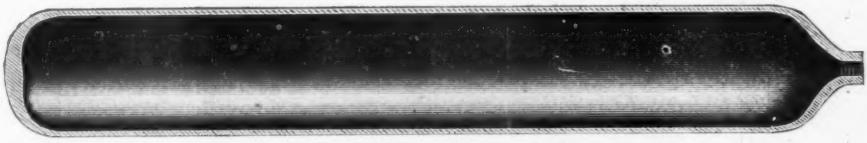

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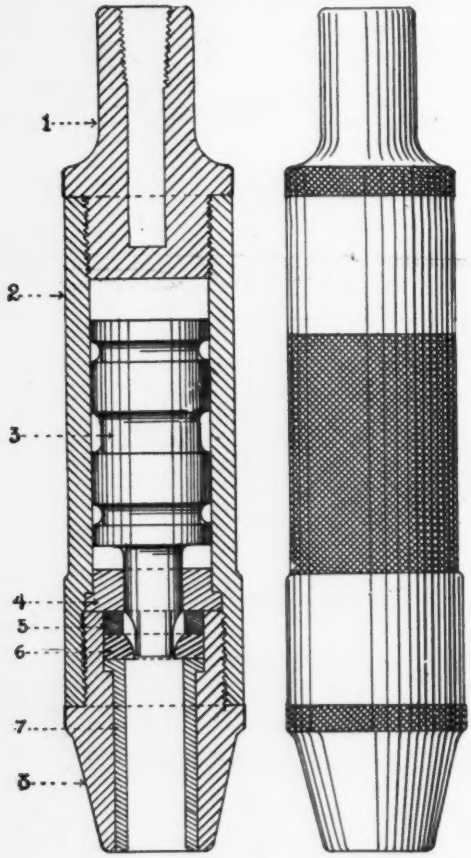

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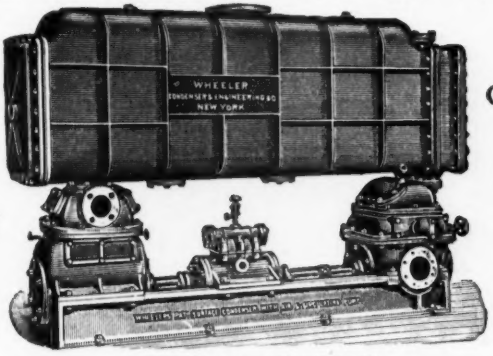

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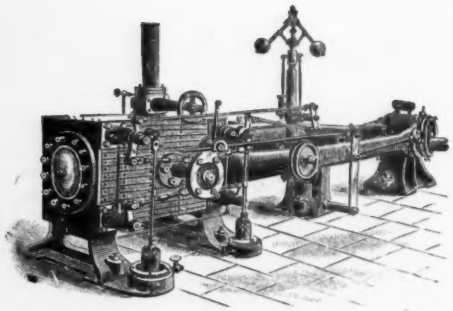

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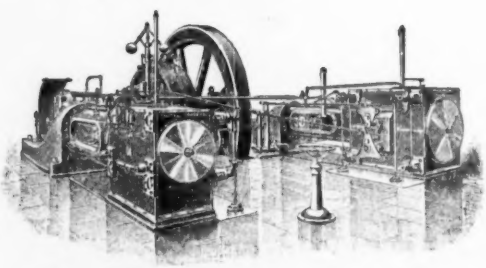

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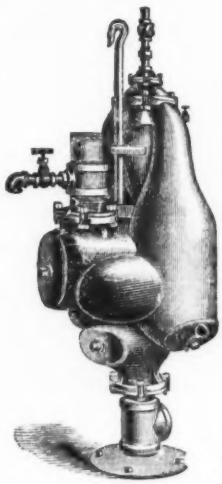

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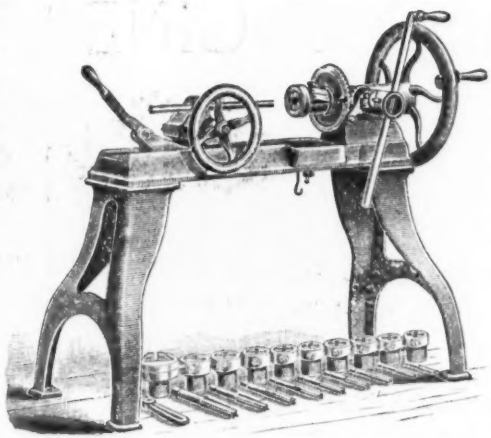

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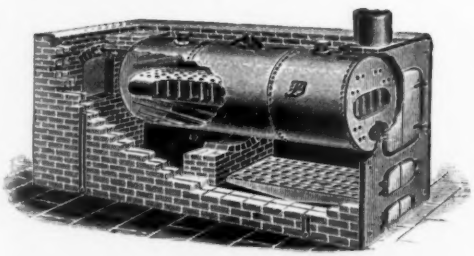

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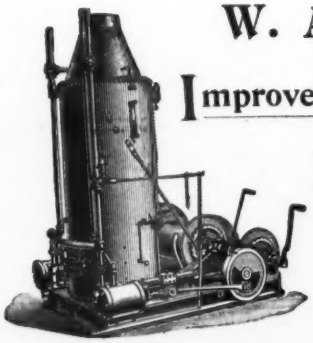

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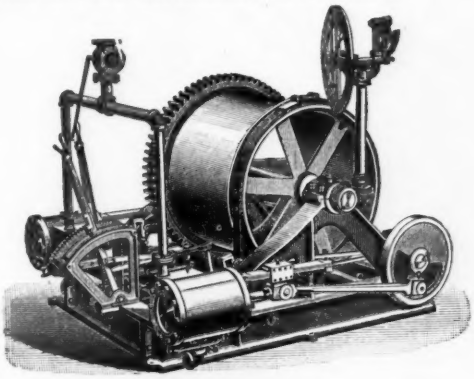

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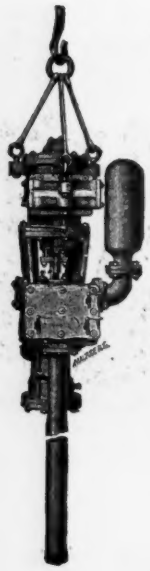

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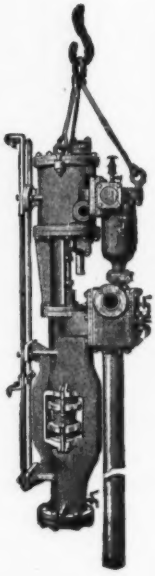

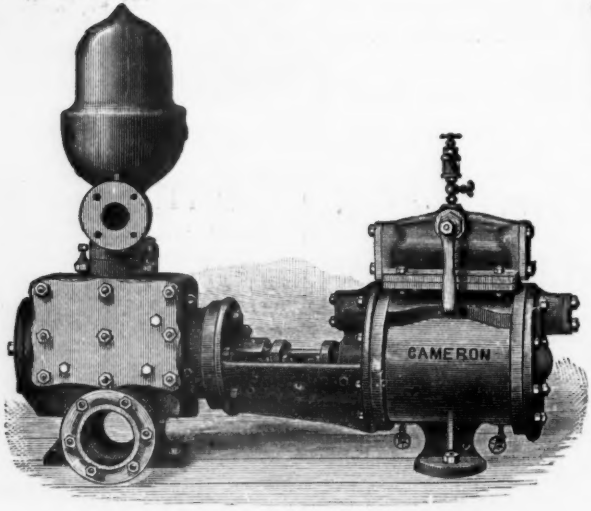

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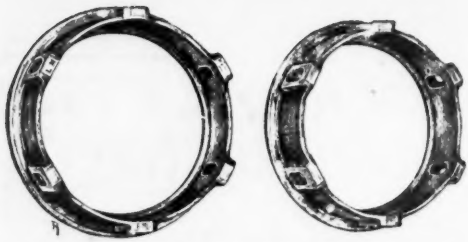

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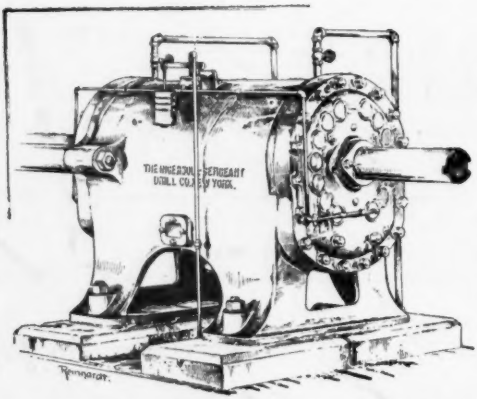

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